CONTRIBUTIONS

FROM THE

CUSHMAN LABORATORY

FOR

FORAMINIFERAL RESEARCH

VOLUME 6, PART 2
JUNE 1930

CONTENTS

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CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

90 Brook Road, Sharon, Mass., U. S. A.

JOSEPH A. CUSHMAN, Sc.D., *Director*
ALICE E. CUSHMAN, *Secretary, in charge of Publications*
RUTH TODD, M. S., *Research Associate*

These Contributions will be issued quarterly. They will contain short papers with plates, describing new forms and other interesting notes on the general research work on the foraminifera being done on the group by the workers in this laboratory. New literature as it comes to hand will be briefly reviewed.

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CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

90. NOTES ON UPPER CRETACEOUS SPECIES OF VAGINULINA, FLABELLINA AND FRONDICULARIA FROM TEXAS AND ARKANSAS

By Joseph A. Cushman

Like most regions which have marly or chalky phases of Upper Cretaceous deposits, the Gulf Series of Texas and Arkansas as well as the equivalent formations of the southeastern United States, are rich in these genera. Large species of *Frondicularia, Flabellina* and *Vaginulina* occur and are a striking constituent of washed residues from the marls and chalks. Most of the species while widely distributed in both hemispheres have nevertheless rather restricted vertical ranges. For this reason and their comparatively large size, they form excellent markers of horizons and restricted formations.

As a study of these groups is in progress, it has seemed advisable to give short notes and figures of some of these species so that they may be made available for the many workers now dealing with these Cretaceous deposits. Through the purchase of the Schmitt collection consisting of more than a thousand tubes of German material, much of it Cretaceous, as well as material kindly furnished by Drs. A. Franke and R. Paalzow from German deposits, it is possible to get a fairly good understanding of the many species described and figured by Reuss and others. Through my own collecting and the kindness of others, the representation of French and English Cretaceous species is extensive, and gives adequate suites of the species described by d'Orbigny and others to show their variation as well as the typical form. Many of the species have very wide ranges including Europe, Australia and America, while

others seem to be limited to certain regions so far as available material shows. The same conditions obtain in most of our Upper Cretaceous and Lower Cretaceous as well. Ecologic conditions were probably fairly constant over wide areas, and as a result species of foraminifera became very widely distributed. Specialized species were however developed, and these have a more restricted range. For this reason it is impossible to do intelligent work on American Cretaceous material without a careful study of the very considerable literature on European species, and added to this a close study of European material.

For correlation purposes the agglutinated or arenaceous groups are of especial use in the Cretaceous series. Due to changes to greensands, the calcareous species are often entirely obliterated while the arenaceous forms remain. The same is true of the more brackish conditions that prevailed northward in the Dakotas and into Canada, where the arenaceous types persisted. To compare such faunas with those of equivalent age elsewhere, a study of the arenaceous groups is imperative, and the species are of wide distribution. They are not as attractive as the forms noted in this paper, but are of great practical use.

Only a small part of the available species are illustrated and noted here. The others will await the publication of other papers and a further study of European material.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA STRIGILLATA (Reuss)

Plate 4, figures 1, 9, 10

Citharina strigillata Reuss, Verstein. Böhm. Kreide, 1845-6, pt. 2, p. 106, pl. 24, fig. 29.

Test elongate, slender, with slightly convex sides and rounded periphery, the sutures very oblique and slightly raised, broken by numerous short costae, parallel to the straight side of the test; wall of the chambers smooth; aperture slightly drawn out.

Figured specimens are from the Lott Chalk member of the Taylor marl, S. S. W. of Scott, Falls Co., Texas, and from the Upper Brownstown marl of Arkadelphia, Clark Co., Arkansas. This is a widely distributed species in the Upper Cretaceous of Europe, America and probably Australia.

VAGINULINA RECTA Reuss
Plate 4, figure 5

Vaginulina recta Reuss, Sitz. Akad. Wiss. Wien, vol. 46, 1862 (1863), p. 48, pl. 3, figs. 14, 15.

This species has already been noted from the upper part of the Lower Cretaceous of Texas (Contr. Cushman Lab. Foram. Res., vol. 6, 1930, p. 4, pl. 1, figs. 17-22).

Specimens very similar occur in the Austin Chalk, especially in the lower Gober which may be referred here.

VAGINULINA SIMONDSI Carsey
Plate 4, figures 6-8

Vaginulina simondsi Carsey, Univ. Texas Bull. 2612, 1926, p. 40, pl. 2, fig. 4.

Test with the sides flattened, broadest toward the apertural end, periphery bi- or tri-carinate, dorsal edge straight, ventral edge somewhat curved, slightly lobed; chambers fairly distinct, sometimes hidden by the surface ornamentation; sutures fairly distinct, strongly oblique, not raised; wall ornamented, especially in the early half by a few strong costae, becoming somewhat oblique toward the dorsal margin, later chambers with a larger series of finer costae; aperture somewhat extended, at the dorsal border.

This is related to the following species. It is fairly common in some parts of the Navarro formation. It has a variable form and ornamentation, especially of the later chambers. Our figured specimens are from the Brownstown marl, 1 mile E. of Ben Lomond, Sevier Co., Arkansas.

VAGINULINA WEBBERVILLENSIS Carsey
Plate 4, figure 14

Vaginulina webbervillensis Carsey, Univ. Texas Bull. 2612, 1926, p. 39, pl. 2, fig. 7.

Test very large, flattened, broadest toward the apertural end, periphery usually bi- or tri-carinate in the young, often becoming rounded in the adult, dorsal edge straight, ventral edge much convex; chambers numerous, elongate, curved, distinct; sutures slightly limbate, curved strongly backward; wall smooth except at the initial end which may have a few costae; aperture protruding somewhat, on the dorsal angle.

This is a fine large species and an excellent marker for the upper

part of the Navarro formation of Texas above the Nacatoch Sand and of the Arkadelphia clay of Arkansas. Bagg has recorded this species from the Upper Cretaceous of New Jersey as "*Vaginulina strigillata* Reuss". I have specimens over 7 mm. in length. There is considerable variation in the outline of the test.

VAGINULINA MULTICOSTATA Cushman, n. sp.
Plate 4, figure 4

Test small, compressed, pointed at both ends, dorsal edge straight, ventral edge strongly convex; chambers elongate, curved, the last-formed one reaching back half way to the base along the ventral margin; sutures distinct, very oblique, curved, slightly limbate; wall ornamented with many fine costae parallel to the straight dorsal edge of the test; aperture slightly produced.

Length of holotype 1.70 mm.; breadth 0.30 mm.

Holotype from Upper Cretaceous, Old Canton Landing, Alabama River, Ala. Holotype Cushman Coll. No. 22215.

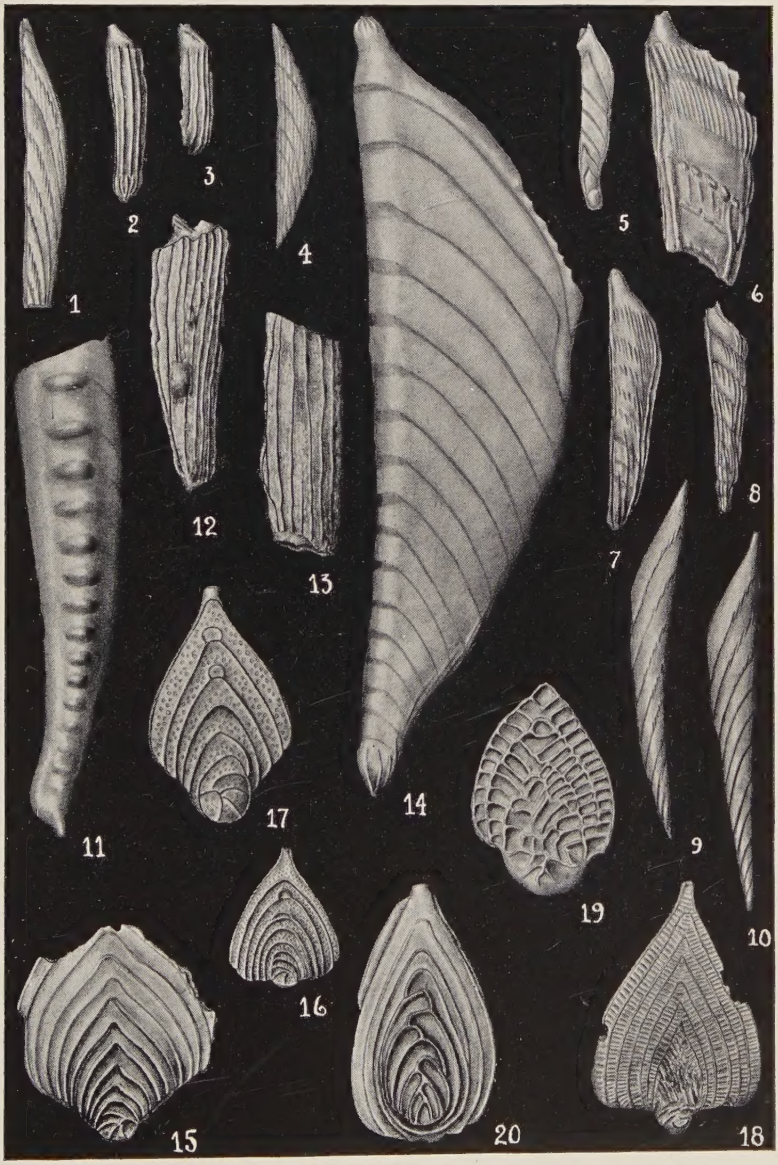
This is a very striking, small, delicate species with numerous, very fine, longitudinal costae. In outline it closely resembles the figures given by Beissel under "*Frondicularia strigillata*" Plate XVI, figs. 23-27, but is not like the figures given by Reuss for that species.

EXPLANATION OF PLATE 4

Unless otherwise noted, all figures × 18

FIGS. 1, 9, 10. *Vaginulina strigillata* (Reuss).
FIGS. 2, 3. *Vaginulina texana* Cushman, n. sp. Fig. 2, Holotype.
FIG. 4. *Vaginulina multicostata* Cushman, n. sp.
FIG. 5. *Vaginulina recta* Reuss.
FIGS. 6-8. *Vaginulina simondsi* Carsey.
FIG. 11. *Vaginulina* (?) *trilobata* (d'Orbigny) (?).
FIGS. 12, 13. *Vaginulina* sp (?).
FIG. 14. *Vaginulina webbervillensis* Carsey.
FIG. 15. *Flabellina rugosa* d'Orbigny.
FIGS. 16, 17. *Flabellina interpunctata* von der Marck. Fig. 17, Young. × 35.
FIGS. 18, 19. *Flabellina reticulata* Reuss. Fig. 19, Early stages. × 50.
FIG. 20. *Kyphopyxa christneri* (Carsey).

Figures drawn by Margaret S. Moore.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VAGINULINA TEXANA Cushman, n. sp.
Plate 4, figures 2, 3

Test elongate, compressed, very slightly tapering, initial end tapering to a point, periphery keeled; chambers few, obscured by the ornamentation which consists of a few high, prominent costae running from the initial end to the middle of the last-formed chamber, the outer end smooth; sutures indistinct; aperture at the dorsal margin, produced.

Length of holotype 1.30 mm.; breadth 0.25 mm.

Holotype from the Lower Gober, Austin Chalk, Barham Road, 2.3 miles W. of Petty, Lamar Co., Texas, collected by Dr. L. W. Stephenson. Holotype, Cushman Coll. No. 22216.

This is a very striking species, apparently undescribed, and constant in its form and characters. It somewhat resembles d'Orbigny's *Marginulina raricosta,* but the specimens of this species I have from the French Cretaceous are rounded in section and belong to *Marginulina,* while the Texas species is strongly compressed and a true *Vaginulina.*

VAGINULINA sp (?)
Plate 4, figures 12, 13

The specimens figured are incomplete. They represent a large, stout, species with numerous, somewhat irregular costae. They are from the Upper Gober, Austin Chalk, 2.2 miles West of High, Lamar Co., Texas.

VAGINULINA (?) TRILOBATA (d'Orbigny) (?)
Plate 4, figure 11

The figured specimen seems to belong to *Vaginulina,* and is referred to d'Orbigny's figure with some doubt. Typical French material seems to be closer to *Marginulina* as are Mexican specimens also. These however are, as shown in the figure, closer to *Vaginulina.* They are from the Navarro in the marl above the Nacatoch sand, Mexia highway, 2.8 miles E. S. E. of Coolidge, Limestone Co., Texas, collected by Dr. L. W. Stephenson.

Genus FLABELLINA d'Orbigny, 1839

FLABELLINA INTERPUNCTATA von der Marck
Plate 4, figures 16, 17

Flabellina interpunctata VON DER MARCK, Verh. nat. Ver. preuss. Rheinl., vol. 15, 1858, p. 53, pl. 1, fig. 5.—REUSS, Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 216, pl.

9, fig. 1—Heron-Allen and Earland, Journ. Roy. Micr. Soc., 1910, p. 422, pl. 8, fig. 5.—Franke, Bronn. Verh. Nat. Hist. Ver., vol. 59, 1912 (1913), p. 277.—Chapman, Bull. Geol. Surv., W. Australia, No. 72, 1917, p. 34, pl. 10, fig. 91.—Franke, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 64, pl. 5, fig. 13; Jahrb. preuss. Geol. Landes., vol. 48, 1927, p. 678; Abhandl. preuss. Geol. Landes., vol. 111, 1928, p. 92, pl. 8, fig. 17.—White, Journ. Pal., vol. 2, 1928, p. 203.

Flabellina rugosa Beissel (not d'Orbigny), Abhandl. Kön. Preuss. geol. Landes., vol. 3, 1891, p. 47, pl. 9, figs. 20-24.

Frondicularia projecta Carsey, Univ. Texas Bull. 2612, 1926, p. 41, pl. 6, fig. 5.

Frondicularia baudouiniana Cushman (not d'Orbigny), Contr. Cushman Lab. Foram. Res., vol. 2, 1926, p. 21, pl. 3, fig. 5; Journ. Pal., vol. 1, 1927, p. 155, pl. 24, fig. 13.

Test sagittate to rhomboid in outline, much compressed, sides nearly flat, periphery truncate; early chambers coiled, later ones extending back on both sides; sutures raised and sharp, later chambers with a loop or series of loops at the apical end of the chamber; wall between the raised sutures with a series of small papillae; apertural end slightly projecting.

This is a very characteristic species with its raised, clear-cut sutures and the papillate wall. The peculiar loop-like extensions in the median line in the adult are also characteristic even if the papillae are covered.

The Mexican specimen figured by White as "*Flabellina delicatissima* Plummer" is probably *F. interpunctata.*

Midway specimens are much like this species, and probably identical.

There is a great variation in form in this species. In some specimens the adult chambers reach to the line of the proloculum as in Pl. 4, fig. 16, while more commonly the test is rhomboid as in the younger specimens, as in Pl. 4, fig. 17.

Flabellina interpunctata is a widely distributed species occurring in Europe, Australia and America. It is a characteristic species of the Taylor marl of Texas and equivalent formations elsewhere; in the Mendez of Mexico; Annona Chalk, Upper Gober and Lower Navarro of Texas as well as the typical Taylor; Upper Brownstown marl, Ozan, and Saratoga Chalk of Arkansas; Selma Chalk of Alabama; and the Upper Cretaceous of Florida in wells.

FLABELLINA RETICULATA Reuss
Plate 4, figures 18, 19

Flabellina reticulata Reuss, in Haidinger's Nat. Abhandl., vol. 4, pt. 1, 1851, p. 30, pl. 1, fig. 22; Sitz. Akad. Wiss. Wien, vol. 44, pt. 1, 1861 (1862), p. 326.—Olszewski, Sprawozd. Kom. Fizyj. Akad. Umiej. Krakowie, vol. 9, 1875, p. 110.—Egger, Abhandl. Kön. bay. Akad. Wiss. München, Cl. II, vol. 21, 1899, p. 107, pl. 13, figs. 5-7.—Franke, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 64, pl. 5, fig. 14; Abhandl. Preuss. Geol. Landes., vol. 111, 1928, p. 93, pl. 8, fig. 19.—White, Journ. Pal., vol. 2, 1928, p. 204, pl. 28, fig. 15.

Frondicularia reticulata Bagg, Bull. 88, U. S. Geol. Survey, 1898, p. 50, pl. 3, fig. 6.—Weller, Geol. Survey New Jersey, Paleontology, vol. 4, 1907, p. 230, pl. 2, fig. 30.—Plummer, Univ. Texas Bull. 2044, 1927, pp. 39, 172, pl. 2, fig. 5.

Flabellina favosa Beissel, Abhandl. Kön. Preuss. geol. Landes., vol. 3, 1891, p. 49, pl. 19, figs. 25-28; pl. 26, fig. 28.

Frondicularia cf. *interpunctata* Cushman (not von der Marck), Bull. Amer. Assoc. Petr. Geol., vol. 10, No. 6, 1926, p. 598, pl. 20, fig. 6.

Test much compressed, sides nearly or quite flat, outline of test variable, periphery truncate; early portion coiled, later chambers extending back on both sides; chambers distinct; sutures distinct, raised somewhat, the surface of the test between covered by a raised net work of octagonal meshes with the long axis at right angles to the sutures; aperture slightly produced.

This is a widely distributed species in Europe and America. It is characteristic of the Navarro formation of Texas above the Nacatoch Sand, and occurs in Arkansas in the lower part of the Arkadelphia clay.

Pl. 4, fig. 18 shows an adult, and fig. 19, the early stages of another specimen more enlarged to show the details of the net work.

FLABELLINA RUGOSA d'Orbigny
Plate 4, figure 15

Flabellina rugosa d'Orbigny, Mém. Soc. Géol. France, sér. 1, vol. 4, 1840, p. 23, pl. 2, figs. 4, 5, 7.

There are many references to this species described by d'Orbigny from the Cretaceous of France. The figures given by d'Orbigny show some peculiarities. The side view shows a very thin test of about equal thickness throughout, and his figures of *F. baudouiniana* show a very much thickened early portion. The sutures in the material we are referring to *F. rugosa* are very much raised over the early sutures, then are progressively reduced until in the adult the sutures are very low or may

even be depressed. Such specimens are characteristic of the chalks of Europe and of the Cretaceous of America, and seem best referred to d'Orbigny's *F. rugosa.*

Flabellina rugosa is often very abundant in the Taylor marl of Texas, and occurs also in the Upper Ozan of Arkansas and in the Upper Cretaceous in wells of Florida and Mexico.

Genus KYPHOPYXA Cushman, 1929

KYPHOPYXA CHRISTNERI (Carsey)

Plate 4, figure 20

Frondicularia christneri Carsey, Univ. Texas Bull. 2612, 1926, p. 41, pl. 6, fig. 7.

Kyphopyxa christneri Cushman, Contr. Cushman Lab. Foram. Res., vol. 5, 1929, p. 1, pl. 1, figs. 1-7.—Church, Journ. Pal., vol. 3, 1929, p. 411.

This species described originally from the Cretaceous of Texas is now known from Texas, Arkansas, Florida and California. It occurs in the Taylor and Austin Chalk of Texas and in the Brownstown marl and Ozan of Arkansas.

Genus FRONDICULARIA Defrance, 1824

FRONDICULARIA MICRODISCA Reuss

Plate 5, figure 4

Frondicularia microdisca Reuss, Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 195, pl. 5, fig. 4.

The figured specimen from the Lott Chalk member of the Taylor marl is from 3.5 miles, air line, S. S. W. of Scott, Falls Co., Texas, collected by L. W. Stephenson. It is an unusually broad specimen, but shows the size and form which this species may assume. The wall is smooth, and many of the chambers come down to the level of the proloculum. It also occurs in the Middle Annona Chalk of Texas.

FRONDICULARIA GOLDFUSSI Reuss

Plate 5, figure 3

Frondicularia goldfussi Reuss, Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 192, pl. 4, fig. 7.

This is one of the large, smooth, broad species of the Cretaceous of Texas. It occurs in the Taylor marl above Marlin Chalk member, and

in the Lott Chalk as well as in the Upper Gober tongue of the Austin Chalk. In Arkansas it has occurred in the Brownstown marl.

The proloculum is usually below the other chambers at the basal line even when the specimens are wider. The walls are smooth and the sutures distinctly convex but not raised.

FRONDICULARIA CORDAI Reuss

Plate 5, figure 17

Frondicularia cordai Reuss, Verstein. Böhm. Kreide, vol. 1, 1845-46, p. 31, pl. 8, figs. 26-28; pl. 13, fig. 41; vol. 2, p. 108, pl. 24, fig. 38.

This species has the greatest width toward the base, and has the test longitudinally costate. There is much variation in the outline of the test from cordate to lanceolate. It is most common in the Austin Chalk.

FRONDICULARIA CLARKI Bagg

Plate 5, figures 1, 2

Frondicularia clarki Bagg, Johns Hopkins Univ. Circulars, No. 121, 1895, p. 2; Bull. 88, U. S. Geol. Survey, 1898, p. 48, pl. 3, fig. 4.

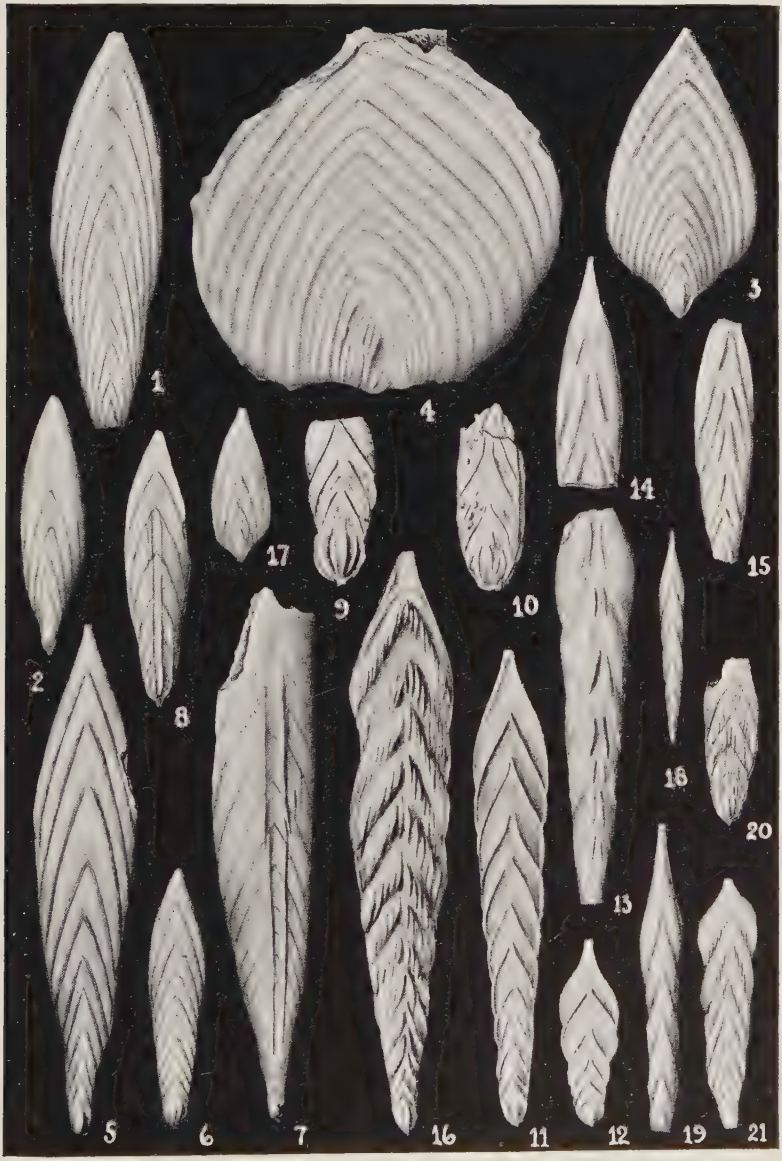
This species was described by Bagg from the Cretaceous of New Jersey, from the Monmouth formation of Atlantic Highlands. It is a smooth species of rather peculiar shape, with a prominent proloculum and the chambers of the adult very elongate and convexly curved in an

EXPLANATION OF PLATE 5

All figures × 18

Figs. 1, 2.	*Frondicularia clarki* Bagg.
Fig. 3.	*Frondicularia goldfussi* Reuss.
Fig. 4.	*Frondicularia microdisca* Reuss.
Figs. 5, 6.	*Frondicularia verneuiliana* d'Orbigny.
Figs. 7, 8.	*Frondicularia verneuiliana* d'Orbigny, var. *fossata* Cushman, n. var. Fig. 7, Holotype.
Figs. 9-12.	*Frondicularia archiaciana* d'Orbigny.
Figs. 13-15.	*Frondicularia verneuiliana* d'Orbigny, var. *bidentata* Cushman, n. var. Fig. 13, Holotype.
Fig. 16.	*Frondicularia gracilis* Franke.
Fig. 17.	*Frondicularia cordai* Reuss.
Figs. 18, 19.	*Frondicularia lanceola* Reuss.
Fig. 20.	*Frondicularia decheni* Reuss.
Fig. 21.	*Frondicularia angusta* (Nilsson) (?).

Figures drawn by Margaret S. Moore.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easily distinguished type of curve. The curvature of the sutures and chambers will easily distinguish it from the following species.

In Texas the species occurs in the marl above the Nacatoch Sand in the Navarro formation.

It should be noted that the peculiar structure described by Bagg of a tube connecting with the aperture is probably an attached organism.

FRONDICULARIA VERNEUILIANA d'Orbigny

Plate 5, figures 5, 6

Frondicularia verneuiliana D'ORBIGNY, Mém. Soc. Géol. France, sér. 1, vol. 4, 1840, p. 20, pl. 1, figs. 32, 33.

This smooth species was originally described by d'Orbigny from the French chalk which is the equivalent of the Taylor marl of Texas, and identical in many of its species. The form is somewhat similar to the preceding, but the sides are subacute and it is thickest in the middle, the sutures raised and nearly straight instead of showing the peculiar convexity of the preceding. The chambers are also shorter. In the French specimens I have, the sutures are often very strongly raised.

This species is characteristic of the Taylor marl and Annona Chalk of Texas as well as in the Ozan formation of Arkansas.

FRONDICULARIA VERNEUILIANA d'Orbigny, var. FOSSATA Cushman, n. var.

Plate 5, figures 7, 8

Variety differing from the typical in having a channel along the middle of each broad face with a costae on each side.

Holotype of variety from the Upper Taylor, 20 feet above the top of the Marlin Chalk member, Waco road, 1 mile W. S. W. of Prairie Hill, Limestone Co., Texas, collected by Dr. L. W. Stephenson. Holotype of variety, Cushman Coll. No. 39459.

This is clearly allied to the above species, and is found with it. The middle groove has the bounding costae often somewhat interrupted.

Frondicularia pinnaeformis Chapman from the Gault also has a median channel, but the other characters are totally different from ours.

FRONDICULARIA VERNEUILIANA d'Orbigny, var. BIDENTATA Cushman, n. var.
Plate 5, figures 13-15

Variety differing from the typical in having the upper ends of the sutures thickened and projecting above the surface in a series of paired, short ribs.

Holotype of variety from the Austin Chalk, Upper Gober, cut on Texas and Pacific R. R. 2.2 miles W. of High, Lamar Co., Texas, collected by Dr. L. W. Stephenson. Holotype of variety, Cushman Coll. No. 39457.

There is some variation in this variety as shown. The thickening of the sutures gives the appearance of a concave line which is not the real curvature of the chambers and sutures.

Similar specimens also occur in the Taylor marl of Texas.

FRONDICULARIA GRACILIS Franke
Plate 5, figure 16

Frondicularia angusta Reuss (not Nilsson), Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 196, pl. 4, fig. 5.

Frondicularia archiaciana d'Orbigny, var. *strigillata* Bagg (not *F. strigillata* Reuss), Bull. 88, U. S. Geol. Survey, 1898, p. 47, pl. 3, fig. 5.

Frondicularia gracilis Franke, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 50, pl. 4, fig. 9.

The above references evidently all refer to this highly ornamented and beautiful species. The proloculum has several coarse costae, and the following chambers have the sutures raised, then broken by longitudinal costae which in the adult become limited to the chamber surface and the sutures become depressed. There is a considerable variation in the amount and complexity of the ornamentation, but its essential characters are shown in our figure and in those quoted above.

It is widely distributed in the Upper Cretaceous, but its vertical range does not appear to be great. Bagg's specimens were from the Rancocas formation of Vincentown, New Jersey. In Texas, it is characteristic of the Taylor marl, the Lott Chalk member having very fine specimens, and also from just above the Marlin Chalk member. It is one of the most striking of our species.

FRONDICULARIA ARCHIACIANA d'Orbigny
Plate 5, figures 9-12

Frondicularia archiaciana d'Orbigny, Mém. Soc. Géol. France, sér. 1, vol. 4, 1840, p. 20, pl. 1, figs. 34-36.

This seems to be the first available name of the many that have been applied to this widely distributed species. The curvature of the sutures is characteristic. They are raised above the general surface and are sigmoid, the areas between smooth and depressed, the periphery truncate and the apertural end produced. Such specimens are characteristic of the Upper Taylor of Texas, and similar specimens occur in the Upper Ozan of Arkansas.

FRONDICULARIA LANCEOLA Reuss

Plate 5, figures 18, 19

Frondicularia lanceola Reuss, Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 198, pl. 5, fig. 1.

This is a very slender, lanceolate species with the apical end much produced. The sides are often much more lobulated than in the figured specimens. Usually the wall is smooth, but as is shown in Reuss's type figure there may be faint costae developed. The peripheral margin is rounded or subacute.

This species is characteristic of the Taylor marl, Annona Chalk, and Austin Chalk of Texas.

FRONDICULARIA DECHENI Reuss

Plate 5, figure 20

Frondicularia decheni Reuss, Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 191, pl. 4, fig. 3.

This species has raised sutures, and the area between the sutures with a few costae. The diameter of the test increases very gradually, and the base is usually provided with a stout spine.

The figured specimen is from the Brownstown marl of Arkansas, and the species also occurs in the Taylor marl of Texas.

It resembles *F. archiaciana* d'Orbigny, but has the surface ornamentation.

FRONDICULARIA ANGUSTA (Nilsson) (?)

Plate 5, figure 21

The figured specimen from the Brownstown marl is referred with some question to the not very well defined species of Nilsson. The sutures have broken costae giving the test a costate appearance. Such specimens are widely distributed, and show a considerable degree of variation.

91. THE DEVELOPMENT OF HANTKENINA IN THE CRETACEOUS WITH A DESCRIPTION OF A NEW SPECIES

By Joseph A. Cushman and R. T. D. Wickenden*

Peculiar specimens with spinose projections have been known for some time from the Cretaceous of Europe, and have been referred to *Siderolina*. The Eocene specimens frequently referred to "*Siderolina kochi* Hantken'" belong to the genus *Hantkenina* known to occur in the Upper Eocene and the lowest Oligocene of Europe and North and South America. Of the Cretaceous specimens referred to "*Siderolina cenomana* Schacko", little has been known. Through the discovery of similar specimens in the Cretaceous of southern Manitoba during the work of the junior author, an excellent series of specimens has been available for detailed studies. The species is a small one, but by persistent effort more than fifty specimens have been found in this material.

A study of this series and comparison with the figures given by Schacko and Egger make it clear that at least two Cretaceous species are present. Schacko's species is from the Cenomanian, and has a very similar early development to the later Cretaceous species. In some respects it is a more primitive one. There are four chambers in each coil, while the later Cretaceous one has but three. The final chamber in the Cenomanian species loses the tubular extension, and becomes more or less globular.

Hantkenina has been derived, at least theoretically, from a coiled, planispiral form as has also *Heterohelix* and the more specialized genera of the Heterohelicidae. This relationship is borne out by the occurrence of these species of *Hantkenina* in the Cretaceous and in the Canadian material accompanied by *Heterohelix americana* (Ehrenberg).

So far as can be made out, the tubular extensions in these Cretaceous forms are not closed at the outer end although this may be due to breakage. However, those covered by later chambers are apparently

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not closed, and it can hardly be possible that these have suffered breakage as they are protected by the wall of the outer chamber.

Descriptions of the two Cretaceous species follow:

HANTKENINA CENOMANA (Schacko)
Plate 6, figures 1-3

Siderolina cenomana Schacko, Arch. Ver. Freunde Nat. Mecklenburg, vol. 50, 1896, p. 161, pl. 4, figs. 3-5.

Test small, planispiral, involute; chambers four in the last-formed coil, globular in the early stages, drawn out into long tubular processes, the final chamber globular and lacking a tubular process; wall calcareous, smooth, finely perforate; aperture a low arch at the base of the last-formed chamber in the median line. Diameter about 0.25 mm. in largest specimen figured.

This species occurs in the Cenomanian of Moltzow, Germany. Egger figures a specimen from the Senonian of southern Germany which he referred to *Siderolina cenomana*. It is not the same as the specimens that Schacko had, and it may be closely related to the Canadian species since it occurs in material of almost the same age. However, Egger's figure is inconclusive as it lacks essential details.

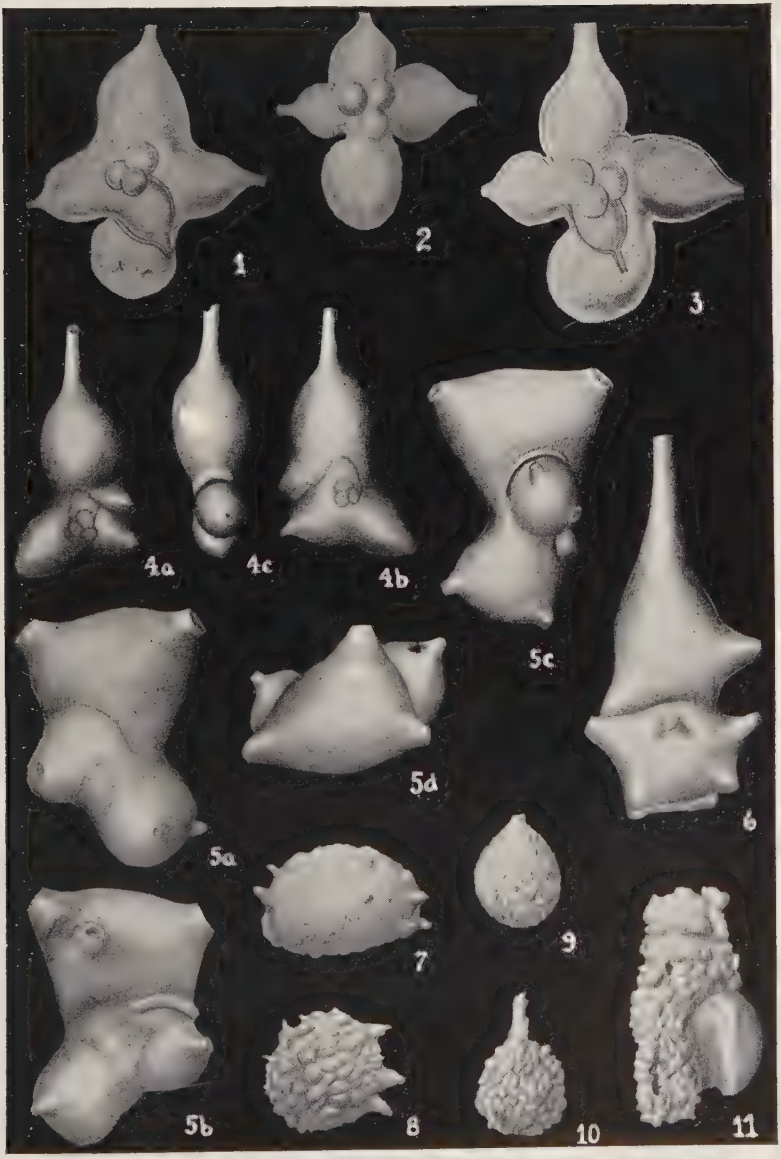
HANTKENINA MULTISPINATA Cushman and Wickenden, n. sp.
Plate 6, figures 4-6

Test planispiral in general, the adult chambers sometimes slightly out of alignment, earlier chambers globular but very early developing a distal tubular extension, in general in a radial position, later chambers polyhedral and with as many as five tubular processes, three

EXPLANATION OF PLATE 6

Figs. 1-3. *Hantkenina cenomana* (Schacko). (After type figures.)
Figs. 4-6. *Hantkenina multispinata* Cushman and Wickenden, n. sp. Figs. 4 *a-c*, Young. × 200. Figs. 5 *a-d*, Holotype. × 140. Fig. 6, × 120. Shows adult chamber with five processes.
Fig. 7. *Thurammina phasela* Moreman. × 50
Fig. 8. *Thurammina irregularis* Moreman. × 50.
Fig. 9. *Lagenammina stilla* Moreman. × 50.
Fig. 10. *Lagenammina sphaerica* Moreman. × 50.
Fig. 11. *Raibosammina mica* Moreman. × 50.

Figures drawn by Margaret S. Moore.


1
2
3
4a
4c
4b
5c
5d
6
5a
7
9
5b
8
10
11

chambers making up each coil; sutures fairly distinct, slightly depressed; wall smooth, calcareous, thick, finely perforate; aperture a low arched opening at the base of the chamber, in the earlier stages in the median line but in the adult extending outward to the umbilical area at least on one side, with a thin lip over the opening. Length of adult about 0.24 mm.; thickness at umbilicus 0.09 mm.; at periphery of last chamber 0.18 mm.

Holotype.—From N. E. ¼, Section 11, T. 6 N.; R. 8 W. of principal Meridian on North bank of Boyne River, southern Manitoba. Holotype in collection of National Museum of Canada, Ottawa. Paratypes in the collection of the Cushman Laboratory for Foraminiferal Research, Sharon, Mass.

With the help of the figures, the following definite stages may be made out:

Nepionic.—Proloculum globular, nearly or quite spherical followed by at least two chambers of a similar form and nearly equal size.

Neanic.—The next succeeding chamber becoming elongate in a radial direction, bluntly pointed but apparently without a definite, tubular process, succeeding chambers carrying this structure to a constantly higher degree until the chamber is longer than broad, constricted toward the proximal end and expanded in the middle, thence tapering distally into a comparatively large tubular extension.

Ephebic.—The form keeps to the general planispiral development, but the chambers become much expanded, greatly broadened at right angles to the axis of coiling and irregularly polyhedral, a tubular projection developed from each of the angles with five as the maximum seen in the series of specimens studied.

Gerontic.—A very few of the largest specimens show an irregularity of the chamber somewhat greater than in the ordinary adults, and may perhaps represent a gerontic character. One of the largest specimens shows an actual reduction of the processes to three in the last-formed chamber after having attained an adult chamber with five processes.

The species has also occurred at several other localities in Manitoba. The "Chalk" was called the Cheval formation by McLean in 1916. Earlier writers have referred this formation to the Niobrara. There are very few megafossils in the formation, and none of these are good index fossils. The microfauna may be compared with the Taylor formation of Texas and the fauna described by Ehrenberg in his Mi-

krogeologie, 1854, which was probably from the Niobrara Chalk on the Missouri River. As numerous species of this fauna are known from the Gulf Series of Texas, it is to be expected that *Hantkenina multispinata* will later be found in that region.

The northernmost occurrence is in a band of calcareous shale on the south bank of the Vermillion River, ½ mile above the crossing of the trail into the Riding Mountain Forest Reserve. This occurrence occupies about the same stratigraphic position as the "Chalk" 150 miles further south. The range is limited to these beds, as no specimens were found from any other formation in the Prairie Provinces.

92. NOTES ON EARLY PALAEOZOIC FORAMINIFERA

By Joseph A. Cushman

A paper by W. L. Moreman in the Journal of Paleontology (vol. 4, No. 1, March 1930, pp. 42-59, pls. 5-7) entitled: "Arenaceous Foraminifera from Ordovician and Silurian Limestones of Oklahoma" is of unusual interest. Various forms have been described from early Palaeozoic strata, but for the most part these are referred to genera which are known to be calcareous, perforate types and secreted by the animal itself. The figures of these early forms are in some cases very inaccurate, for example, the so-called "Globigerinas" and "Orbulinas" of Matthew from the Cambrian, which are figured as having the surface characters of these genera, are probably nothing but minute phosphatic nodules without structure, so far as the specimens I have seen named by Matthew show. Some of the other specimens from the Silurian referred to *Lagena,* etc., may as appropriately belong to such forms as *Proteonina,* etc.

The forms described by Chapman from the Devonian of New South Wales (Proc. Linn. Soc. New South Wales, vol. 43, 1918, pp. 385-391, pls. 39-41) are referred to the genera *Psammosphaera, Valvulina* and *Pulvinulina.*

The figures of all of these seem to indicate that the wall may be agglutinated, and even the *"Pulvinulina"* is described as having "a finely granulate shell-wall" in the present state. Chapman notes that Terquem's specimens from the Devonian were all casts. As such, they

give little clue to the real species, and some at least may have been radiolarians.

In contrast to these very indefinite early forms, the material described by Moreman is of a distinctly definite character. Through his kindness, I have topotypes of most of his new species in my collection here. The figures given by Moreman do not do full justice to the excellently preserved specimens in which the detailed structure is as perfect as in Recent material. The grains of which the tests are made are shown in the fullest detail. There can be no question as to the generic position of the forms referred to *Thurammina*, nor of the arenaceous character of the other forms. A few of these topotypes are drawn here (Pl. 6, figs. 7-11) to show the details of the wall, not clearly shown in the original figures.

The very striking thing about all these specimens is that they are not only agglutinated or arenaceous forms, but that they belong to the most primitive of the arenaceous groups. If these are replaced by silica, and calcareous, perforate forms occurred with them, it is certainly to be expected that they would be equally well preserved as siliceous replacements.

Both free and attached forms are present which agree very closely with similar arenaceous forms in Post-Palaeozoic and Recent deposits. Altogether the whole assemblage is a most striking and consistent one, and of just the sort that would be expected in the early Palaeozoic where these primitive arenaceous forms originated long before the calcareous perforate forms were developed.

The possibilities opened up by Moreman's studies are very fascinating. It is probable that by the same methods, other limestones will be found to be equally prolific in these early primitive, arenaceous forms, and that we may soon learn more of their history in the early Palaeozoic where they evidently formed the foraminiferal fauna. From these came the abundant fauna of arenaceous foraminifera in the Carboniferous and Permian, and traces of the intermediate forms should be discovered by a series of similar studies in the Pre-Carboniferous limestones.

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works that have come to hand.

van Rijsinge, C.
Die Foraminiferen aus dem Senon Limburgens. VIII. Rhabdammina cretacea n. sp.
(Nat. Maan., Nat. Gen. Limburg, Jaarg. 17, No. 7, July 27, 1928, pp. 98-101, 1 plate). *Limburg.*
Describes and figures a new species from the Cretaceous of Holland.

van Rijsinge, C.
Some Remarks on Dictyoconoides, *Nuttall* (=Conulites, *Carter* =Rotalia, *Lamarck*).
(Ann. Mag. Nat. Hist., ser. 10, vol. 5, Jan. 1930, pp. 116-135, pls. V, VI, 12 text figs.). *London.*
Many detailed figures of early stages are given and described.

Gerth, H.
The Stratigraphical distribution of the larger Foraminifera in the Tertiary of Java.
(Proc. Fourth Pacific Science Congress, 1929, pp. 591-599). *Bandoeng.*

A resumé with tables showing distribution of species.

Casasnovas, G. Colom
Nota sobre las Calizas con Miliolas del Estampiense de Mallorca.
(Mem. Real Soc. Espanola Hist. Nat., vol. 15, Dec. 20, 1929, pp. 237-240, pl. XII). *Madrid.*
Notes occurrences, and figures sections.

Cushman, Joseph A.
Note sur quelques Foraminifères Jurassiques d'Auberville (Calvados).
(Bull. Soc. Linn. Normandie, ser. 8, vol. 2, 1929, pp. 132-135, pl. IV). *Caen.*
Figures and describes two new species and a new genus, *Nubeculinella.*

Hucke, K.

Uber die Mikrofauna der Septarientonshichten, welche bei der Tiefbohrung am Wasserwerk Dessau durchsunken wurden.

(Bericht. Nat. Ver. Dessau, Heft 2, 1930, pp. 14-17). *Dessau.*

Lists foraminifera and ostracodes found at various depths in boring.

Silvestri, A.

Fauna paleogenica di Vasciano presso Todi. Pt. II.

(Bull. Soc. Geol. Ital., vol. XLVIII, 1929, fasc. 2, 1930, pp. 185-232, 2 figs.). *Roma.*

Numerous forms are described, mostly Camerinidae and Orbitoididae, three new.

Galloway, J. J. and Charles Ryniker.

Foraminifera from the Atoka Formation of Oklahoma.

(Oklahoma Geol. Survey, Circular No. 21, Jan. 1930, pp. 1-37, pls. I-V). *Norman.*

Several new species, and a new genus, *Endothyranella*, are described and figured.

Cushman, Joseph A. and William W. Valentine.

Shallow-water Foraminifera from the Channel Islands of Southern California.

(Contr. Dept. Geology, Stanford Univ., vol. 1, No. 1, Feb. 28, 1930, pp. 1-51, pls. 1-10, map). *Stanford University.*

Several new species are described, and a new genus, *Dyocibicides.*

Cushman, Joseph A. and Roscoe E. and Katherine C. Stewart.

Tertiary Foraminifera from Humboldt County, California. A Preliminary Survey of the Fauna.

(Trans. San Diego Soc. Nat. Hist., vol. VI, No. 2, Feb. 28, 1930, pp. 41-94, pls. 1-8, chart). *San Diego.*

Ninety species and varieties are described, a few of which are new.

Galloway, J. J. and Bruce H. Harlton.

Endothyranella, A Genus of Carboniferous Foraminifera.

(Journ. Pal., vol. 4, No. 1, March 1930, pp. 24-28). *Austin.*

Various species already described are placed in this genus.

Cushman, Joseph A. and Norman L. Thomas.
Common Foraminifera of the East Texas Greensands.
(l. c., 1930, pp. 33-41, pls. 3, 4). *Austin.*
Nine species described and figured from the Eocene, three new.

Moreman, W. L.
Arenaceous Foraminifera from Ordovician and Silurian Limestones of Oklahoma.
(l. c., 1930, pp. 42-59, pls. 5-7). *Austin.*
Thirty species of thirteen genera are described and figured. A new family, Stegnamminidae, three new genera, *Stegnammina, Raibosammina* and *Colonammina,* and twenty-seven new species of arenaceous foraminifera are described.

Stewart, Roscoe E. and Katherine C.
Post-Miocene Foraminifera from the Ventura Quadrangle, Ventura County, California. Twelve New Species and Varieties from the Pliocene.
(l. c., pp. 60-72, pls. 8, 9). *Austin.*
Figures and descriptions of the twelve forms are given.

Heron-Allen, E. and Arthur Earland.
Some New Foraminifera from the South Atlantic, III. Miliammina, A New Siliceous Genus.
(Journ. Roy. Micr. Soc., ser. 3, vol. 50, pt. I, March 1930, pp. 38-45, pl. 1). *London.*
Four species are described and figured, three new.

Heron-Allen, E. and Arthur Earland.
The Foraminifera of the Plymouth District, I.
(l. c., 1930, pp. 46-84, pls. I-III). *London.*
Twelve species and varieties are noted, with four new.

J. A. C.